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ACQUISITION OF A DISCRIMINATION UNDER DIFFERENT PROCEDURES BY MENTALLY RETARDED ADULTS

BY

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The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies for acceptance, a thesis entitled "Acquisition of a Discrimination Under Different Procedures by Mentally Retarded Adults" submitted by Donald Burfoot in partial fulfillment of the requirements for the degree of Master of Education.

Abstract

Methods were compared for teaching moderately mentally retarded adults to discriminate the position of a 2 by 1.5 in. black rectangle, and respond by pressing a key. Three groups of 13 *S*s were given different training procedures. One group (Group III) was given trial and error experience on the discrimination task followed by an errorless training programme. The second group (Group II) was given the errorless training programme only, and the third group (Group I) no prior training. All three groups were then given the task of learning the discrimination on a trial and error criterion sequence. Analysis of variance and chi-square tests showed that Group II acquired the discrimination most easily. Group III, with a history of errors, experienced more difficulty than Group II, while Group I, with no prior training, had the most difficulty in acquiring the discrimination.

Variations in the ease of acquisition were observed as the number of trials required for *S*s to respond at better than chance performance. When responses began to come under the control of the stimuli, acquisition was equally rapid across all groups. Each group contained mongoloid and non-mongoloid (mostly brain damaged) retardates. No differences were observed in the performances of *S*s due to source of retardation.

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INTRODUCTION

Resources devoted to the welfare of the mentally retarded have been rapidly increasing, resulting in broader facilities for training and education (*Dominion Bureau of Statistics*, 1968; see also Katz, 1968, p. 34, and Farber, 1968, for similar developments in the U.S.A.). To make the best use of these facilities, it is suggested that an understanding of the learning processes of mental retardates is a prime requisite. To this end, Staats (1968) suggested that a full analysis of learning behaviour must first be made. He continued by pointing out that a schism exists between basic experimentalists and applied psychologists that is "an obstacle to [the] growth . . . [p. 559]" of such research, and that he strongly believes that there is "a common basis, in methodology and in theory and in the events which they [experimentalists and applied researchers] study [p. 559]." that may result in the dissolution of the schism.

To the extent that basic experimental techniques are employed in the study of part of the behavioural repertoire of mental retardates from which principles of value to applied research could emerge, studies by Touchette (1968, 1969), and Sidman and Stoddard (1967), using procedures developed by Terrace (1963*a*, 1963*b*), may be seen as a move in the direction suggested by Staats (1968). This study followed the procedures used by Touchette (1968) with mentally retarded children in an extension to mentally retarded adults, and was designed with the comments of Staats (1968) in mind, whereby principles of value in the development of practical techniques were of primary concern.

The Problem

Staats (1968) has pointed out that many approaches to experimental research in learning have concentrated on the acquisition of simple behaviour in animals. It follows that experimental design is more easily applied to complex human behaviour using similar techniques if the tasks to be performed are kept simple. Such behaviour may be found in young children and mental retardates. Although it is not suggested that the behaviour of mental retardates is any less complex than that of others, the tasks they are taught to perform are often sufficiently simple that there may appear to be more opportunity for the application of experimental techniques in mental retardation than in some other areas.

The problem this study attempted to investigate was the acquisition of a simple discrimination. Studies with mental retardates (Ellis, Girardeau & Pryer, 1962; House & Zeaman, 1958, 1960; Orlando, 1961) have reported that discriminative learning has failed to take place even when *S*s have been presented with carefully programmed response contingent reinforcers. Touchette (1968), however, using procedures reported by Hively (1962) and Terrace (1963*a*, 1963*b*), showed that if the learning programme was so designed that the acquisition was essentially error free, retarded children were able to acquire a simple discrimination more easily than those allowed to make errors. The role of errors was thus suggested to be an important factor in the study of human learning in general, and of particular importance in the problem of discriminative learning by mental retardates.

Two aspects of the problem were central to the present study; one was whether a process of error-free learning can be more effective than learning with errors, and the other whether a history of errors can affect that process. Specifically, the questions which this study addressed were whether a group of mentally retarded adults could acquire a simple discrimination more or less easily under errorless learning conditions than a similar group attempting the same discrimination by trial and error, and whether a third group subjected first to the trial and error method and then to the programme that produced error-free learning, differed in ease of acquisition from either of the two former groups.

Need for the Study

Holland has stated:

> Shaping stimulus control has proven to be a specially fruitful research area yielding not only excellent practical techniques but making basic contributions to understanding discrimination learning without errors, transfer of stimulus control, and continuous repertoires [1965, p. 74].

The problem of application of practical techniques arising from principles established by research in this area has yet to be investigated; however, it seems clear from the literature that for research in discriminative learning by stimulus shaping in humans, attention has focused on young children and mental retardates; it is suggested, therefore, that these groups may be prominent in the development of applied programmes. This study is the result, in part, of the need to identify the groups that may benefit from application of basic principles as they become established, and to describe the conditions under which certain techniques may be useful.

Discrimination learning without errors and transfer of stimulus control are part of a basic research area where experimental studies with humans are relatively few in number, and where replication by further research is rare (Sidman & Stoddard, 1967). A number of subtle variations have recently been used by investigators (discussed later) working with techniques for transfer of stimulus control; this study attempted to combine some of these procedures using a novel group of *S*s.

Holland (1965) suggested that elimination of errors is only a valid objective if it is accompanied by the establishment of behaviour whereby the learner overcomes his difficulties. It follows, therefore, that the need exists to clarify empirically the role of errors in human learning in order to determine whether it is a deleterious role or otherwise; observing the conditions under which certain groups are affected by errors may contribute to such a need. Touchette (1968, 1969) and others have recognized the need to investigate the problem, and their results indicate that for mentally retarded children there are certain principles that could be usefully applied to learning situations for the groups concerned.

In addition to the need for development of practical techniques and establishment of basic principles, studies in this area have provided confirmation for the analysis of continuous repertoires by Skinner (1953). Such a contribution to the general scientific approach to human behaviour is, according to Holland, "The greatest significance of these studies . . . [1965, p. 73]."

Operational Definitions

Error frequency. The number of first incorrect responses per unit trial over a defined sequence of trials, usually expressed as a percentage.

Discrimination criterion. A sequence of stimuli of up to 500 trials or 10 consecutive correct responses, whichever is achieved first, intended to define and quantify the acquisition of the discrimination.

Learning the discrimination. The quantifiable behaviour, with respect to the discrimination, increasingly coming under the control of the stimulus, as indicated by an observed decrease in error frequency from that of chance behaviour.

Measure of acquisition of the discrimination. The number of trials on the discrimination criterion sequence; a quantity, between 10 and 500 inclusive, inversely proportional to the ease of acquisition.

Having learned the discrimination. Ten consecutive correct responses to the discrimination criterion stimuli.

Failure to learn the discrimination. Completion of 500 trials on the discrimination criterion with less than 10 consecutive correct responses to the stimuli.

Trial. A correct response to the discrimination stimulus independent of the number of preceding incorrect responses.

Graduated training programme. Twenty stimuli graduated from an easily acquired multi-dimensional display to a single-cued display (see Figs. 2 & 3, pp. 15 f.).

History of errors. An experience of 100 trials, by trial and error on the terminal (criterion) stimulus (see Fig. 1, p. 14), in an unsuccessful attempt to learn the discrimination, preceding the graduated training programme.

Errorless behaviour. No more than 10% incorrect responses to the stimuli over a defined sequence.[1]

Effects of a programme. Behavioural changes which can be validly ascribed to the use of a programme when other sources of influence have been ruled out by appropriate scientific procedures.

Stimulus control. "Stimulus control refers to the extent to which the value of an antecedent stimulus determines the probability of occurrence of a conditioned response [Terrace, 1966, p. 271]."

Mode. A spatial condition, left or right, of the stimulus display, manipulanda, and associated electronic circuitry. A display is in the left (left/upper) mode when either the complex stimulus is to the left of the display panel, or the terminal (criterion) stimulus is to the top of the panel (see Fig. 2, p. 15). A display is in the right (right/lower) mode when either the complex stimulus is to the right of the display panel, or the terminal stimulus is to the bottom of the panel (see Fig. 3, p. 16).

Correct response. Depression of the left key with the stimulus display in the left mode, or the right key with the display in the right mode.

Incorrect response. Depression of the left key with the stimulus display in the right mode, or *vice versa*.

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[1] Behaviour has been referred to as errorless when the errors are few and may be ascribed to transient spurious stimuli that effect no lasting behavioural control. For discussions of "virtually errorless" behaviour see Terrace (1963*a*, 1966), Sidman and Stoddard (1967) and Touchette (1968).

Mongolism. A record of the Industrial Research and Training Centre, Edmonton, Alberta, showing a diagnosis of Down's syndrome.[2]

Non-mongolism. A record of the Industrial Research and Training Centre, Edmonton, Alberta, showing a diagnosis of mental retardation due to brain damage or causes other than Down's anomaly (see Footnote 2).

Assumptions and Hypotheses

For the purposes of this study it was assumed that acquisition of a discrimination is a factor in the general learning process, and that discrimination is a factor in the total behavioural repertoire. The assumption that mongolism differs definably from non-mongolism was implied (see Footnote 2).

The principle of educing responses to a known or easily learned discrimination and holding the response requirement constant while modifying the stimulus was used. This assumed that the response was a component of *S*'s total response repertoire, and that *S* was capable of making and maintaining the response.

For the purposes of statistical analysis of the data, it was assumed that uncontrolled intervening variables were randomized. The assumptions underlying the statistical models have been described by Winer (1962).

The null hypotheses tested were that: (a) observed differences in the ease of acquisition of a discrimination between two groups of mentally retarded adults with and without programmed learning experience are due to chance alone, and (b) observed differences in the ease of acquisition of a discrimination between two groups of mentally retarded adults with errorless learning and a history of errors are due to chance alone.

The alternate hypotheses tested were that: (a) observed differences in the ease of acquisition of a discrimination between two groups of mentally retarded adults with and without programmed learning experience are due to the different methods of stimulus presentation in training, and (b) observed differences in the ease of acquisition of a discrimination between two groups of mentally retarded adults with errorless learning and a history of errors are due to the different methods of stimulus presentation in training.

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[2] For a discussion of classifications of mental retardation see Benton (1964, pp. 25 ff.); for difficulties associated with diagnoses of mongolism or otherwise, see Jervis (1967), and for the problem of brain damage diagnosis see Schulman, Kaspar and Throne (1965, pp. 4 ff.).

Review of the Literature

Recent studies of discrimination learning have shown that acquisition can take place without errors. On the basis of these studies, the view that stimulus-response learning is only a process of error elimination may be questioned. Skinner (1948, 1961) was the first to suggest that errors may be only products of the teaching methodology, while Holland (1965) and Sidman and Stoddard (1967) have suggested that elimination of errors may make learning easier for those who have difficulty.

Some researchers investigating reinforcement have reported results that may be relevant to the problem of errors. Meyer (1960), Kaess and Zeaman (1960) and others have found that confirmation (feedback) has advantages over no confirmation in discrimination learning. However, a substantial number of studies (Feldhusen & Birt, 1962; Holland, 1960; Hough & Revsin, 1963; McDonald & Allen, 1962; Moore & Smith, 1961, 1962) have failed to show that confirmation has an effect on learning. A common procedure in the latter six studies not found in those reporting advantages for confirmation, is the use of learning programmes which produced low error rates, or virtually errorless learning. These data have led Cummins and Goldstein (1962) and Holland (1965) to suggest that confirmation is more advantageous when "self evaluation" is more difficult.

In a study of different kinds of confirmation, Suppes and Ginsberg (1962) found that children who were required to pick up the alternative item after a response error learned faster than if they were only told they were wrong, indicating that the overt correction response may result in faster learning. This result is similar to findings in studies of correction and noncorrection procedures in discrimination learning by animals, and according to Holland, "may result from decreasing the likelihood of learning incorrect alternatives [1965, p. 90]." The correction procedures used in the present study engendered such an overt correction response following errors.

"Shaping" techniques have often taken the form of reinforcement of behaviour that already exists, or is easily acquired, with a gradual change of the reinforcement schedule to reinforce behaviour that increasingly resembles that which is desired, in order to bring a new response under the control of the stimulus. In discrimination learning this principle has been modified to holding the response essentially constant while changing the reinforcement-

contingent stimulus, whereby part of the behavioural repertoire is brought under the control of a new stimulus without engendering change of the total repertoire. Schlosberg and Solomon (1943) reported discrimination acquisition using such stimulus shaping techniques, followed by Lawrence (1952) and Baker and Osgood (1954). Terrace (1963*a*, 1963*b*) and Moore and Goldiamond (1964), using similar but more refined techniques, achieved errorless acquisition in experiments that showed errorless learning to be easier than learning with errors in animals.

A clear limitation of stimulus shaping techniques that engender unchanging responses is that the desired psychomotor behaviour must first be part of the organism's repertoire, and no opportunity is offered for expansion of that repertoire. Staats (1968) pointed out that the repertoire of young children is relatively undeveloped and the learning process embodies the development of the repertoire. There is no evidence to show that the techniques used in the present study have contributed to learning in such a sense. It may be significant, therefore, that research using stimulus shaping techniques has concentrated on the use of *S*s whose behavioural repertoire is relatively well developed compared to the control exercised over that behaviour. Mental retardates may be considered such *S*s, and the procedures used in this study may be considered useful only to the extent that an advantage is seen in controlling existing behaviour.

Colour desaturation (Terrace, 1963*b*), colour fusing (Suppes & Ginsberg, 1962), intensity fading (Moore & Goldiamond, 1964), focus (Acker, 1966; Israel, 1960), and contrast (Gollin & Savoy, 1968) are among the shaping methods that have been employed to modify or transfer control between simple stimuli. Graduations have also been made by the technique of reducing a multi-dimensional stimulus with many cues–colour, edge, shape, contrast, size and position, for example–to a stimulus in which one of these predominates, and the others are eliminated or reduced to relatively low levels and held constant during acquisition of the discrimination (Sidman & Stoddard, 1967; Touchette, 1968).

An important difference between experiments that have employed the principle of modification or transfer of simple stimulus control and those that have used the principle of reduction of a complex stimulus to a more simple form, is that in the former, training programmes have often been designed from the stimulus of an S–R association that already existed, while programmes for the latter have usually introduced a new stimulus which had,

therefore, to be acquired before or during the training schedule that transferred the basis for the discrimination. Hull (1950) and Lawrence (1949, 1950, 1952) discussed the nature of multi-dimensional stimuli in discriminative learning, and the principle that increasing the dimensions of a stimulus results in a stronger and more easily acquired association between the stimulus and the response. Use has been made of this principle in the present study, as with those of Touchette (1968) and Sidman and Stoddard (1967), in the initial establishment of the S–R association to be modified.

In basic research using stimulus shaping techniques, most studies with human *S*s have commenced with the introduction of a new stimulus, while those using animal *S*s have often reported the experiment subsequent to the initial acquisition of a discrimination. It is not surprising, therefore, to find the literature showing a predominance of programmes using complex stimuli in discriminative learning by humans, and simple stimuli in experiments with animals. Access to a group of humans who already possess a basic discrimination that is free of irrelevant associations may be difficult. One notable exception is cited by Holland in a discussion of stimulus fading in applied studies with young children. He said "A variation in the technique is found when the stimulus to be faded is also new, but less subtle than the stimulus to which control is transferred [1965, p. 72]." The technique referred to was used by Csanyi (1961) to teach Spanish pronunciation using the equivalent English phoneme. The pronunciation response engendered by the visual stimulus was already part of the *S*s' repertoires.

The degree of difficulty of the discrimination to be learned has been carefully chosen in many experiments (Touchette, 1968, p. 39), and is particularly important for those concerned with human *S*s, when training and testing time under controlled environmental conditions may be limited. Clearly a difficult discrimination that takes a long time to acquire could be impractical, while a simple discrimination that is too easily acquired may be insufficiently sensitive to the differences the observer is attempting to measure. Due to the lack of data from which predictions could be made about the degree of difficulty that is suitable for groups of human *S*s in a particular experiment, many experiments have been preceded by pilot research that included collection of data for this purpose. The present study used such pilot research, and followed the pilot study procedures of Touchette (1968) and Sidman and Stoddard (1967) in designing a stimulus with an appropriate degree of difficulty for the *S*s that were used.

Touchette (1968) found in his pilot studies with mentally retarded children that position-based responses were the most probable type of error pattern, and suggested that discrimination of a position-oriented stimulus would be more sensitive to error effects in the learning process than other dimensions. Touchette (1968) used a complex stimulus that was gradually reduced to a single-cued stimulus which retained only the dimension of position as the response cue. The stimulus sequence of the present study followed very closely that of Touchette (1968) in the manner in which the stimulus was reduced, and in the dimensional nature of the terminal stimulus.

Schulman, Kaspar and Throne, discussing various behavioural measures, observed: "Experimental studies of human *S*s, either using the above described measures or more subjective observations, are less numerous than those studies dealing with animal *S*s [1965, p. 25]." Objective measurement may be more difficult with humans than with animals due to the degree and duration of control that the experimenter may be allowed to exercise over the *S* and the experimental environment. Two of the more common measures of learning found in the literature relating to programmed discrimination acquisition with both animal *S*s and human *S*s are error frequency and the total number of trials to a criterion. Both variables are easily quantified, readily measured, and normally occur as an integral part of the *S*'s behaviour during the learning process. This study used the number of trials to a criterion as the measure of ease of acquisition of the discrimination, and zero error frequency for 10 consecutive responses as that learning criterion.

Zeaman (1965) showed learning curves for *S*s with varying degrees of retardation as measured by I.Q. and M.A. He pointed out that once learning the discrimination had commenced, it was quite rapid and equal in rate for all levels of retardation, as demonstrated by the slope of the learning curves. The difference in ease of acquisition appeared to be the number of trials required before learning started. He then conjectured:

> the difference between relatively bright and dull children among retardates is not learning ability but rather a difference in some other process providing a necessary condition for learning. Attention is such a process [Zeaman, 1965, p. 116].

Zeaman and House have both theorized that attention is a necessary precondition for learning among retardates (see for example House, 1964; House & Zeaman, 1960; Zeaman & House, 1963; Zeaman, House & Orlando, 1958). Zeaman (1965) supports the *a priori* argument by the observation that factors controlling attention should therefore also control

performance, as do stimuli. Measurement of performance by the number of trials to a criterion, then, may be a measure of attention to relevant dimensions of the stimulus, and, in the present study, a directly proportional measure of difficulty in attending to the dimension of position; or it may be a measure of other variables inhibiting control by the stimulus, factors that are less simple and less clearly understood among humans.

METHOD

Subjects

Thirty-nine mentally retarded adults, 21 male and 18 female, daytime students attending the Industrial Research and Training Centre, Edmonton, Alberta, served as subjects. Chronological ages ranged from 17 to 53 yr (mean = 24.9 yr). All *S*s had been admitted to the Centre on the basis of diagnosed mental retardation and graduation from the Winnifred Stewart School for the Mentally Retarded, Edmonton, Alberta, or equivalent special education. Most had been in attendance since the opening of the Centre; durations of attendance ranged from 4 to 9 mo (mean = 8.1 mo). I.Q. scores[3] ranged from 21 to 52, and all *S*s were considered to be trainable.[4]

The sample was the total population of the Centre after exclusion of 10 considered to be unsuitable due to physical defects in sight and hearing, those considered to be atypical by reason of a history of I.Q. scores above 68, those with only diagnosed emotional disorders and inconsistent records of performance at the Centre, and those not in attendance at the time of testing due to illness.

Only two *S*s had been institutionalized for a substantial duration, and all were living in homes with parents or guardians. Medical records of the Centre showed 16 *S*s with a diagnosis of mongolism, 18 with diagnosed brain damage, and five with no diagnosed cause of retardation. Before testing, *S*s were stratified by these three categories, and randomly assigned into three groups of 13 each. As there was reason to doubt that all non-mongoloid *S*s had been fully examined for brain damage or otherwise (see Footnote 2, page 5), for the purposes of this study the sample was considered to have only two strata—mongolism and non-mongolism.

To test for serious sight and hearing defects, *S*s were required by verbal instructions to describe the colours of 1.0 by 0.75 in. red, white, blue and black rectangles.

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[3] I.Q. scores were obtained from the records of the Centre, as scores on the Stanford-Binet Intelligence Scale; dates for the test were during the 10-year period prior to admittance to the Centre.

[4] In the educational system of the Province of Alberta, "trainable" means unsuitable for regular school attendance, but suitable for special training. Students at the Centre were in the "Moderate Mental Deficiency", or "Average Mentally Retarded" categories as defined in *Mental Retardation in Canada*, a Report on the Federal-Provincial Conference (1964, pp. 144 & 265).

Apparatus

Each S was seated in a room 12 by 24 ft, with low levels of ambient noise and lighting. The response-display unit, a modified Welch Autotutor Mk. III filmstrip projector with two standard telegraph keys mounted below the screen, was in front of S. Circuitry was activated by depressing a key. For correct responses, relays actuated the projector to move the filmstrip to the next frame. Wrong responses were ineffective, and feedback due to relay noise was eliminated.[5] A photocell decoded the stimulus display as either left or right mode. A simplified schematic of the electronic circuitry appears in Appendix A.

A complete temporal account of the responses and stimulus mode was maintained on a 12-channel Honeywell 2106 Visicorder, and running totals on a bank of 10 Sodeco counters. A delay timer generated a 3-sec timeout from reinforcement conditions following each correct response by extinguishing the projector light, during which period the responses to either key were ineffective.

A constant level of "white" background noise was provided to mask counter and other extraneous noise. The experimenter[6] was seated 6 ft to the right of S, dressed in a blue smock, the standard dress for staff at the Centre.

Stimuli

A three-section filmstrip was made by photographing coloured cards using Kodak Ektachrome film, and black and white cards using Kodak fine grain positive film. Lighting and filters were used to match the black and white density of the two film types. The sequence of left/upper and right/lower modes was selected randomly for all sections, with no more than four consecutive displays in the same mode. The 20-frame coloured programme (graduated training sequence) contained no more than two consecutive stimuli in the same mode. The three sections were joined to allow continuous presentation of the appropriate sections to all Ss by varying the starting point.

All three sections were presented to Group III, two sections—the graduated training programme and criterion discrimination—to Group II, and one section only—the criterion discrimination—to Group I. The first section, for Group III only, was a 100-frame trial and

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[5] By the use of silicon-controlled rectifiers for relays in circuitry for wrong responses.

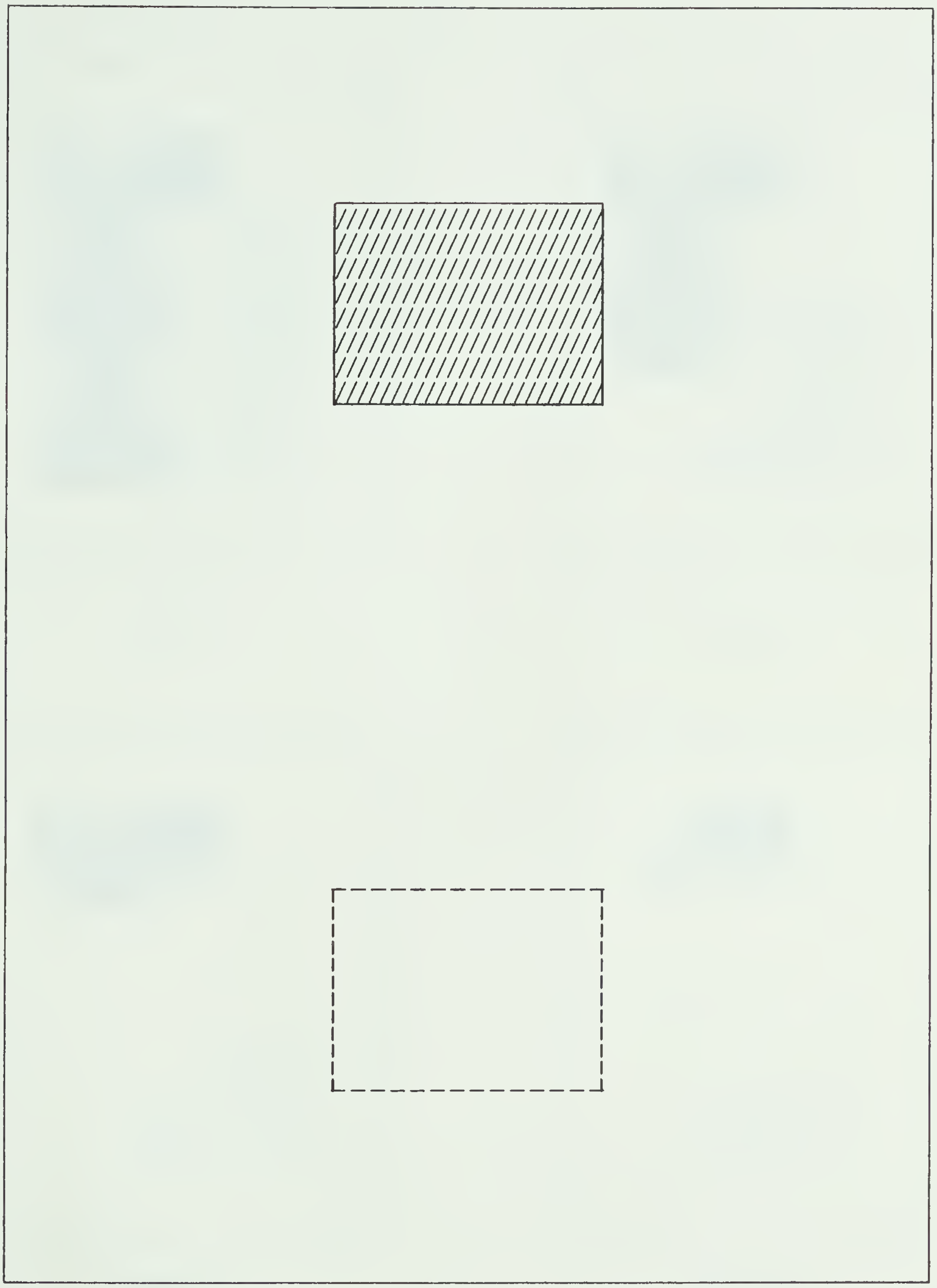
[6] An assistant trained only to present the instructions, operate the equipment, and record the responses.

error sequence; the second section, for Groups II and III, was a 20-frame graduated training sequence; the third section, presented to all groups, was a 250-frame criterion discrimination sequence. Rewinding the third section to allow 500 trials took about 10 seconds. The stimulus for both the trial and error and the discrimination criterion sequences was a display comprized of a white background with a black rectangle located close to either the top or the bottom of the screen (see Fig. 1). The graduated training stimulus was a multi-dimensional display to one side of the screen inclusive of the rectangle of the trial and error sequence. A left-side pattern included the upper rectangle, and a right-side display the lower. The complex stimulus was gradually abbreviated over 20 frames to become identical to the trial and error and discrimination criterion stimulus (see Figs. 2 & 3). A similar sequence has been described by Touchette (1968).

Procedure

The 39 *S*s were tested in random order between the hours of 9 a.m. and 3 p.m. over six consecutive operating days of the Centre. Upon entering the testing room, *S* was seated facing the projector screen and response keys, with the first stimulus displayed. The instructions (see Appendix B) were read by the experimenter, and *S*'s questions were answered by repeating the most appropriate instruction(s). If no response had occurred within 30 seconds, the instruction "Go ahead and press a key" was repeated. Pilot research had indicated that if this procedure was not used, the desired operant could fail to occur.

Each *S* was required to depress the response key corresponding to the position of the displayed stimulus. The criterion was not known by *S*, who was told that he would be rewarded with one dollar if he learned to press the correct key regularly (see Appendix B). Pilot data indicated that intertrial reinforcement of correct responses using small coin was distracting. When a correct response was made, relays were audible, the experimenter said "good", and a 3-sec timeout was initiated, following which the next sequential stimulus was displayed. Incorrect responses produced no contingent event. This correction procedure was used throughout the experiment. A trial was considered complete when a correct response was made. The session was terminated during the discrimination criterion sequence when the criterion of 10 consecutive correct responses or 500 trials, whichever occurred first, had been met.



Scale:- ¾ Actual Size

Fig. 1. Diagram of the stimulus that was used for trial and error experience, the discrimination criterion, and the terminal frame of the graduated training sequence. The shaded area illustrates the position of the black 2.0 by 1.5 in. rectangle in the left/upper mode. The right/lower mode was obtained by inverting the display, as illustrated by the dotted rectangle. The background, referred to as white, was light from the projector bulb through transparent film and the lens system.

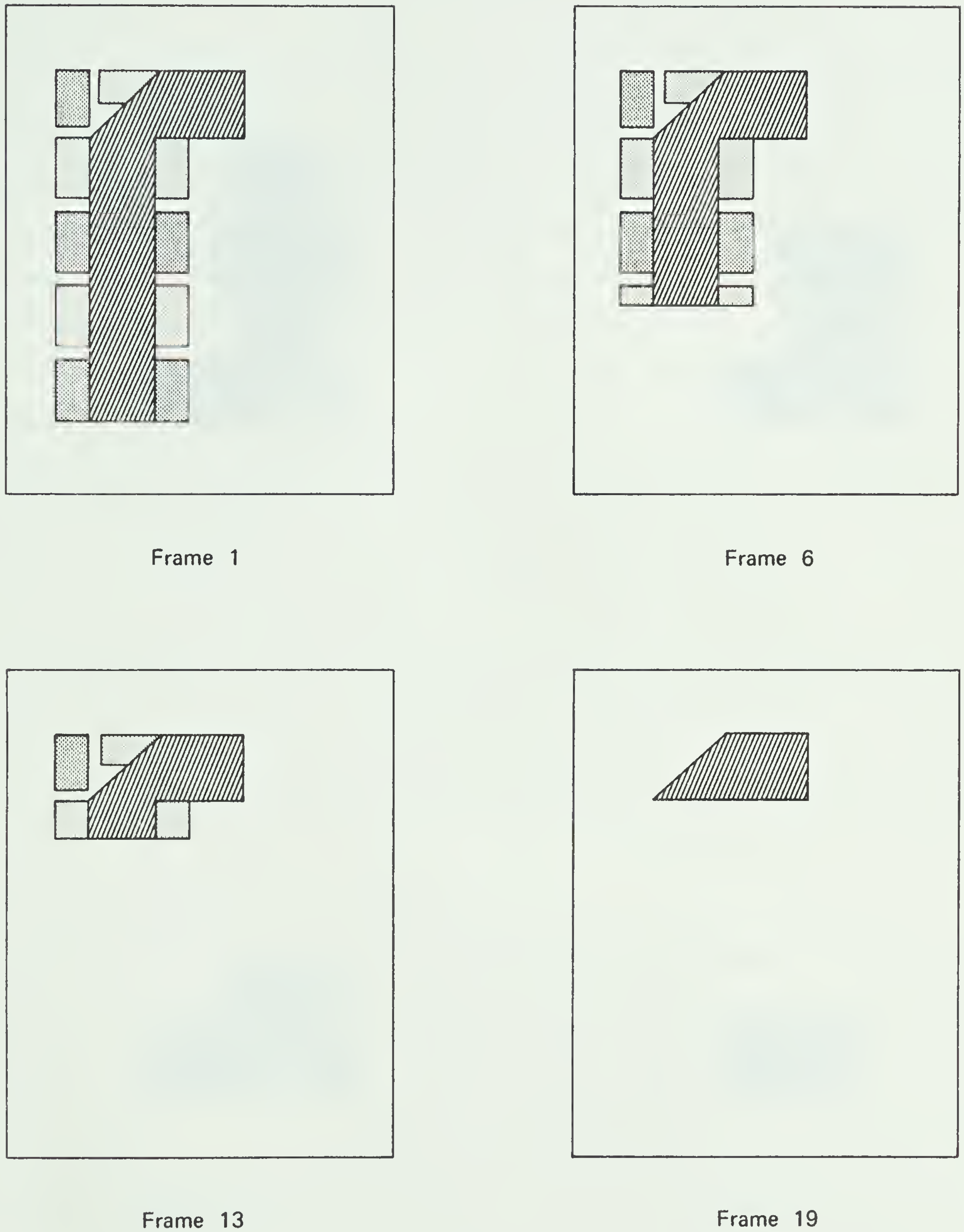


Fig. 2. Diagrams of four of the left/upper stimuli in the graduated training sequence. The smaller rectangles represent alternate blue and red light, the main centre section was black, and the background white light. Each frame was reduced from the previous frame whether it was in the left/upper or right/lower mode, to achieve a gradual transition from frame 1 to the first frame of the discrimination criterion sequence (see Fig. 1).

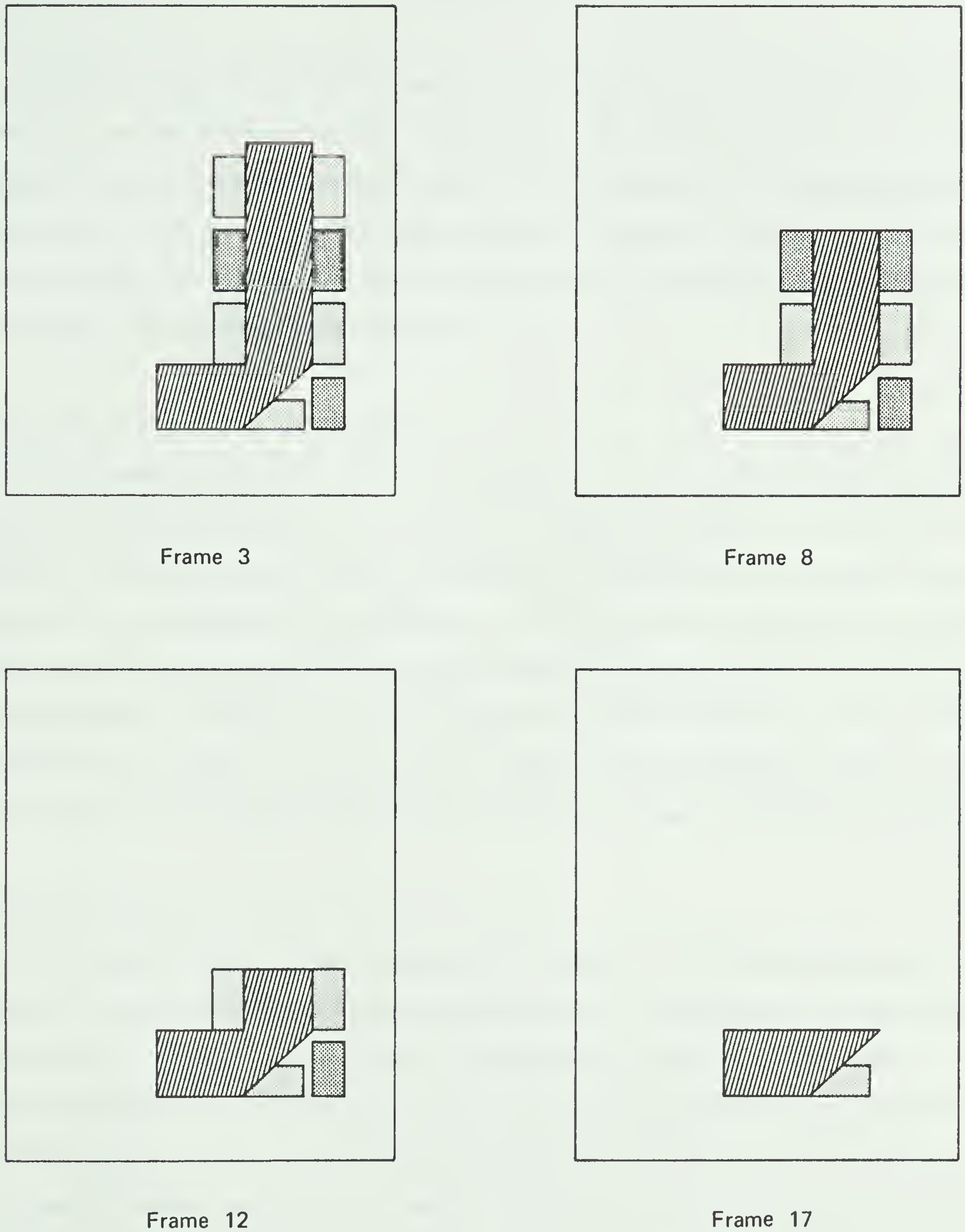


Fig. 3. Diagrams of four of the right/lower stimuli in the graduated training sequence. Right/lower stimuli were obtained by inverting the appropriate left/upper stimuli. Details of the stimuli are described in Fig. 2 (p. 15).

RESULTS

All but three of the 39 *S*s responded to the stimulus by pressing a key following first reading of the instructions by the experimenter. The three who made no immediate response all responded after a second reading of the instruction "Go ahead and press a key [Appendix B]." All *S*s except S6 (discussed below) continued to respond until one of the desired criteria of 10 consecutive correct responses or a total of 500 trials on the criterion discrimination sequence had been achieved.

Trial and Error Experience by Group III

The initial experimental question to be answered was whether the trial and error sequence of stimuli would come to control the response behaviour of Group III *S*s. This occurred in the case of one *S*, S6, a non-mongoloid female with no diagnosed cause of retardation, who learned the discrimination in 25 trials. S6 was not given the graduated training and criterion discrimination sequences, and was assigned a score of 10 trials to learn the discrimination. Analysis of the data showed no difference in the results if S6 was excluded from the study. The trial and error sessions thus established a group of *S*s with a history of errors on the discrimination task and without acquisition of the discrimination.

Graduated Programme Training by Groups II and III

The second experimental question was whether the 20-frame graduated training sequence of stimuli would engender errorless learning by *S*s in Groups II and III. Of the 25 *S*s who were given this sequence, 92% completed the programme with 90% or better accuracy. The two *S*s who failed to achieve errorless learning were both members of Group III, with a history of errors, the worst performance being 75% correct. Table 1 shows the percentage of correct responses and number of errors for all *S*s in Groups II and III. The mean for Group II was 97.7% correct, and for Group III 94.6%. The graduated training sequence of stimuli could then be said to have provided errorless training. Most of the errors that were made appeared in the first few responses of the sequence. The mean course of training for each group is shown in Fig. 4. A small increase in error frequency was observed towards the end of the sequence, particularly among Group III *S*s.

Table 1

Percentage Correct Responses by Groups II and III on the 20-trial Graduated Programme Training Session

Percentage Correct Responses	*Frequency*	
	Group II	*Group III*
100	9	6
95	2	3
90	2	1
85	0	1
80	0	0
75	0	1
Total	13	12

Group II Mean Correct = 97.7%
Group III Mean Correct = 94.6%

Note:- S6, a Group III *S* who learned the discrimination prematurely, is not shown.

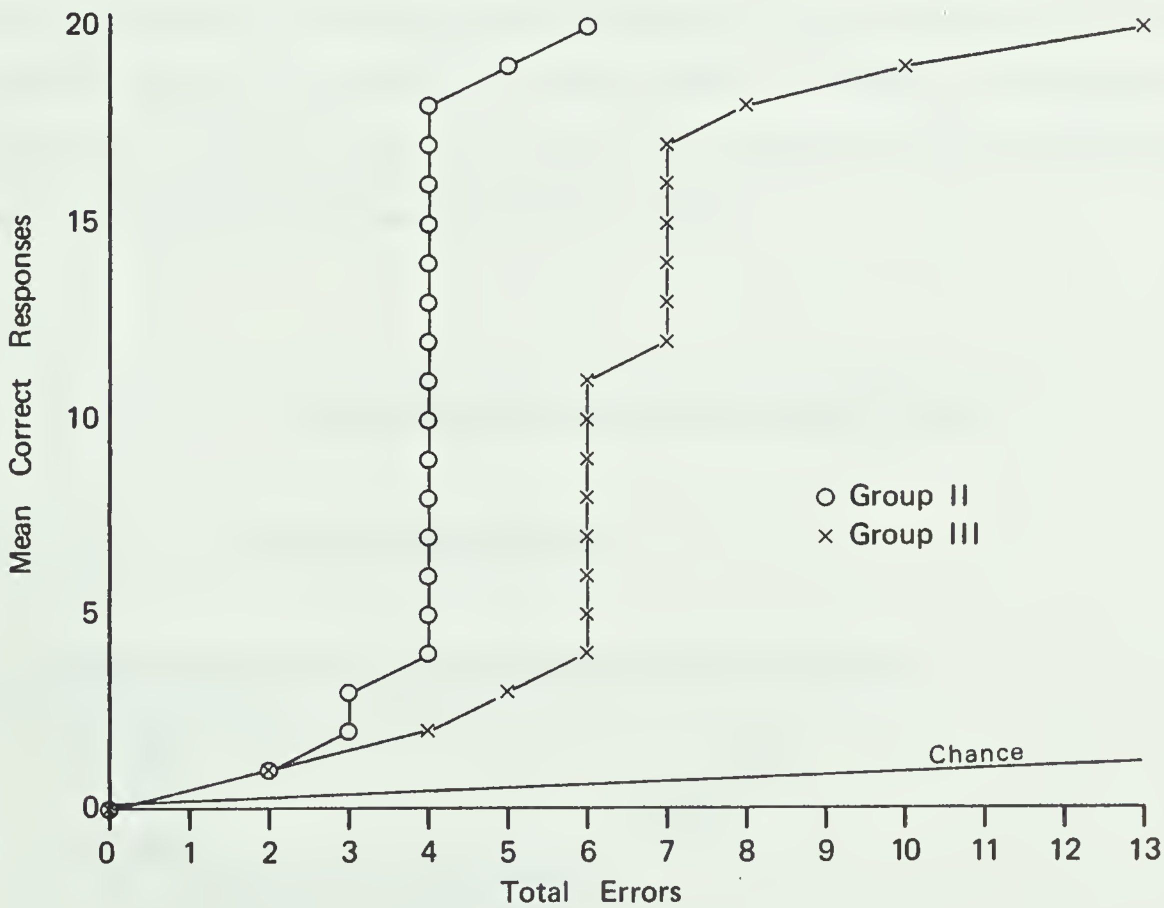


Fig. 4. Mean course of training for Groups II and III on the 20-trial graduated training sequence. *Mean* cumulative correct responses are shown against *total* cumulative errors for each group. Only the first response to a trial has been plotted, and a perfect score for S6 has been included.

Criterion Discrimination by Groups I, II and III

The third experimental question was whether the criterion discrimination sequence would be sensitive to differences between the three groups, and thus provide a measure of acquisition of the discrimination. The number of trials to criterion for each *S* is shown in Table 2 (p. 20). Figure 5 illustrates the mean progression for all three groups through their respective sequences. The minimum score, for a performance with no errors, was 10 trials, the number required to demonstrate acquisition. The maximum score was 500, an indication of failure to acquire the discrimination. The mean scores for Groups I, II and III were 350.9, 136.9 and 286.2 respectively. Since Group I had no previous experience on the discrimination stimuli prior to the criterion discrimination session, the data for this group may be considered to be a measure of the ease of acquisition of the discrimination with no training or history of trial and error experience. Group II data was considered to represent a measure of ease of acquisition with errorless training, and the data for Group III a measure of ease of acquisition with training that was preceded by a history of errors. Five *S*s, or 13% of the sample, made the minimum score of 10 trials to criterion, while 28% scored the maximum of 500 trials. The remaining 59% scored in the range between the two limits, and the procedure was thus considered to have yielded a measure of acquisition of the discrimination. It was then possible to ask whether a difference in ease of acquisition could be shown by comparison of the data for the three groups.

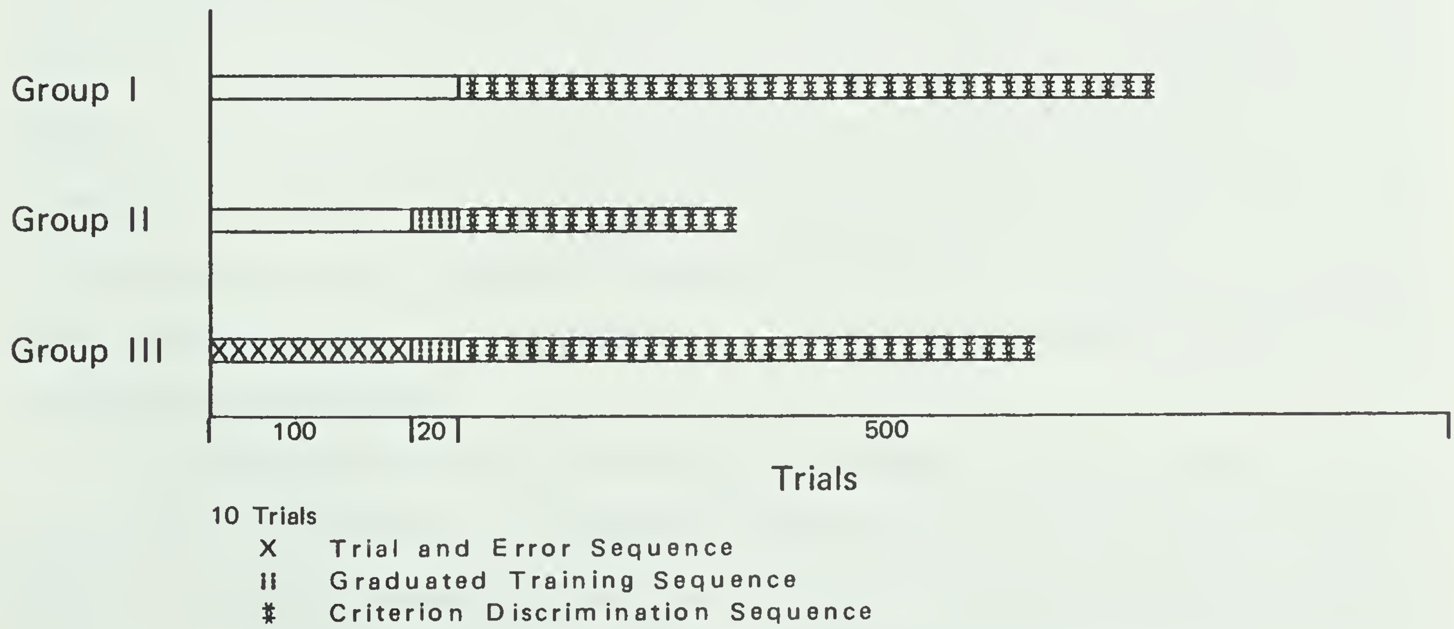


Fig. 5. Mean progression achieved by each group on the discrimination criterion sequence, to the nearest 10 trials. The number of trials to criterion was measured following the three different methods of stimulus presentation, which are also shown. S6 is included.

Table 2

Trials to Criterion for Each Group of Adult Retardates with Two Sources of Retardation

Source of Retardation	*Groups* *I*	*II*	*III*
Non-mongolism	25	10	10*
	73	10	68
	125	27	234
	196	61	262
	500	61	338
	500	95	456
	500	220	500
	500	500	
Mongolism	346	10	55
	367	10	84
	430	41	309
	500	235	405
	500	500	500
			500

Note:- Ten trials represents a minimum score, or best possible performance; 500 trials represents the maximum score, at which time the session was terminated.

* The assigned score for S6.

The condition factor source of retardation was divided into the two levels non-mongolism and mongolism (see Table 2). Four *S*s in Group II responded with no errors, while in Group III only S6, who learned the discrimination without experiencing the graduated training sequence, could be considered to have learned as easily. Two *S*s in Group I scored less than 100, a performance that would have put them in the same category as S6, that of prematurely learning the discrimination, if they had been in Group III. Thus the similarity of frequencies of *S*s in Groups I and III with very good performance could be said to indicate an even distribution of brighter *S*s across groups. Six *S*s in Group I failed to learn the discrimination, three in Group III also scored 500, while in Group II two *S*s failed to achieve acquisition. None of the non-acquirers was performing at better than chance when the session was terminated.

The data indicated that the three groups differed in the ease with which the discrimination of this study was acquired. For both mongols and non-mongols, Group II learned most easily, followed by Group III, with Group I experiencing the most difficulty. The mean scores for the three groups are shown in Table 3 (p. 21) as number of trials to criterion. The performance of non-mongols was superior to that of mongols within all

groups. To test the hypotheses of this study, the means were first tested by a two-way analysis of variance. The factors were group membership at three levels (Groups I, II and III), and source of retardation at two levels (non-mongolism and mongolism). Both factors were assumed to be fixed (for a discussion of the statistical model see *Model I* in Winer, 1962, p. 161). The analysis demonstrated the presence of main effects ($p < .05$) due to the factor group membership only (see Table 4). The same analysis of the data excluding S6, who was assigned a minimum score, did not change the results.

Table 3

Mean Trials to Criterion for the Three Groups of Adult Retardates by Two Levels of Retardation

Source of Retardation (Factor A)	*Groups (Factor B)*			*Row Means*
	I	*II*	*III*	
Non-mongolism	302.375	123.000	266.857	229.174
Mongolism	428.600	159.200	308.833	299.500
Column Means	350.923	136.923	286.231	

Grand Mean = 258.026

Table 4

Summary of Analysis of Variance with Two-way Classification for the Data of Table 2

Source of Variation	*df*	*MS*	*F*
Retardation (A)	1	43019.1	1.263
Groups (B)	2	154768.6	4.545*
A × B	2	7864.9	0.231
Error	33	34049.9	

*$p < .05$

Scheffé's multiple comparison of main effects (Scheffé, 1960) was used to compare the main effects of the three group levels. A difference between Groups I and II was shown ($p < .05$, see Table 5, p. 22), which made it possible to reject the first null hypothesis, that observed differences in the ease of acquisition of a discrimination between two groups of mentally retarded adults with and without programmed learning experience are due to chance alone, while the first alternate hypothesis, that the differences are due to the different methods of stimulus presentation, was supported.

Table 5

Summary of Multiple Comparison of Group Means by Scheffé's Method for the Data of Table 2

Groups Compared	*F*
I – II	4.550*
I – III	0.558
II – III	1.993

*p < .05

The data indicated within-group trends that varied between groups. Early acquirers, or those *S*s scoring less than 250, were most frequent in Group II; Group I contained the most late acquirers, or *S*s scoring 250 or more, while frequencies in Group III were generally between the two former groups (see Fig. 6). The question was then asked whether a difference in ease of acquisition between Groups II and III alone could be demonstrated by comparison of the frequencies of early and late acquirers in each group. The data for Groups II and III were dichotomized about 250 trials to criterion (see Table 6, p. 23). A chi-square test of significance, using Yates's correction for continuity, indicated that such a difference did exist between the two groups ($p < .05$). It was then possible to reject the second null hypothesis, that observed differences in the ease of acquisition of a discrimination between two groups of mentally retarded adults with errorless learning and a history of errors are due to chance alone, while the second alternate hypothesis, that such differences are due to different methods of stimulus presentation, was supported.

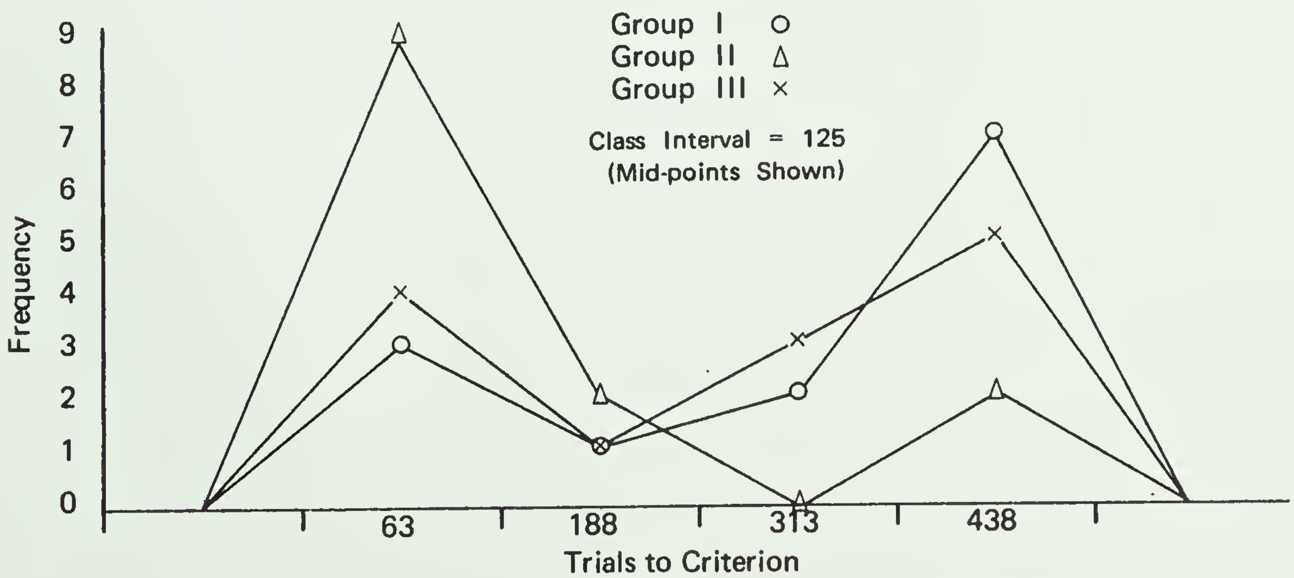


Fig. 6. Frequency distribution for the data of Table 2 in four class intervals of trials to criterion.

Table 6

Summary of Chi-square Test of the Difference Between the Proportions of Early and Late Acquirers in Groups II and III

Group	*Early Acquisition*	*Late Acquisition*	*Group Total*
II	11	2	13
III	5	8	13
Total	16	10	26

Chi Square = 4.0625 ($p < .05$)

Discussion

Sample Limitations

Most problems that were encountered originated with the sample itself. Both mongoloid and non-mongoloid *S*s had large variances in I.Q. scores and records of performance at the Centre, and there were different causes of retardation among non-mongols. A stimulus sensitive to variations near the group mean may be relatively insensitive to differences at the extremes of the range for such a sample. After rejection of those totally unsuitable, the sample of 39 was large enough to suggest some interesting trends in addition to testing the hypotheses, but too small for statistical analysis of the trends. Exclusion of *S*s who were markedly different from the norms for the population at the Centre was considered necessary, but was partly subjective due to limited background information on *S*s. An adequate description of the sample was precluded for the same reason. The possibility exists that *S*s were included who were more competent than the average mentally retarded (see *Mental Retardation in Canada*, 1964, p. 265). However, due to the training and selection processes to which *S*s had been subjected before admission to the Centre, it is improbable that there were any who could be classified as severely mentally retarded, or who would fall substantially below the sample norms.

Subject Selection

To attempt to minimize the limitations due to the nature of the sample, staff members at the Centre were consulted together with the records for each *S*. Those *S*s with suspected emotional anomalies as the cause of retardation that manifested inconsistent performance, whereby *S* could perform at a level which would be atypical of average mental retardates, were excluded. The same procedure of consultation was used to obviate the need to be dependent on the I.Q. scores that appeared in the records. I.Q. scores had been recorded over 10 years, and retardates under the training experiences to which the sample had been exposed may perform increasingly well on I.Q. tests over such a period. I.Q. was not used in this study, therefore, except as a minor aid in the selection of the sample.

Some *S*s were unsuitable due to physical handicaps, and others were excluded following tests described in the Method (p. 11).

Pilot Research–Stimulus Design

The stimuli were designed following pilot research at the Winnifred Stewart School for the Mentally Retarded. Senior adult and adolescent *S*s similar to those at the Centre were used–graduates from the School became eligible to enroll at the Centre. The initial terminal stimulus used at the School was very similar to that used by Touchette (1968), and the degree of difficulty was gradually increased until it became clear that the discrimination was too difficult, whereupon the task was made easier until it appeared to be sensitive to variations in performance of *S*s with a record of performance close to the mean of the population of the School. The graduated training sequence was then made more difficult by reduction in length from 60 to 20 frames by a similar procedure. The dimensions embodied in the sequence have been described, and it was intended to retain those that were included in the Touchette (1968) sequence, while increasing the difficulty by increasing the rate of graduation of the sequence from the initial to the terminal stimulus. The observed need for a more difficult discrimination than that used by Touchette was attributed to his use of younger *S*s who were more retarded than those used in the present study. When the final sequences were constructed, pilot tests at the School indicated that the graduated sequence would allow error-free learning and aid in acquisition of the discrimination, and that measurement of the ease of acquisition could be made.

Data Treatment

The small sample size of the main study was a factor that affected the statistical treatment of the data. Certain procedures, such as analyses without *S*s at the extremities of the data distribution were not meaningful due to the small cell frequencies that resulted if all the data were not used; such treatment is therefore not reported. Yates's correction for continuity was applied to compensate for the small N when using chi square, and certain characteristics of the nature of the acquisition that are not dependent on statistical analysis or a large N are reported.

The initial two-way analysis of variance of the data was intended to attempt to determine whether any more interesting relationships were demonstrable than was possible using a chi-square test between each of the three groups independently, while at the same time providing an indication of differences between groups. Scheffé's multiple comparison of main effects was then used to examine more closely the source of the differences.

Although a difference was clearly shown between Groups I and II using Scheffé's test, the contrast and F ratio were too small to demonstrate a difference between Groups II and III by this procedure. This was attributed to the influence of Group I data on the grand mean, the conservative nature of Scheffé's test, and the small sample size. Since there was no interaction, it was not necessary to retain Group I in the analysis in order to compare the data for Groups II and III to test the second hypothesis. The distribution of the data within Groups II and III indicated a dichotomous situation to which a chi-square test would be sensitive, and this test was used to determine the effect of a history of errors on the acquisition of the discrimination. The deleterious effect of errors under the conditions described in this study were thus shown.

Examination of the data for the purpose of interpretation was a necessary and important part of this study. The primary purpose was to address two explicit questions within the problem of errors among mental retardates; however, because the present body of knowledge leaves a large number of questions unanswered, and many principles unclear, consideration was given to the possibility of the data indicating results about which it would be neither reasonable nor necessary to make predictions. Use of chi square to test the second hypothesis was part of this *a posteriori* process.

Implications

Errorless training made acquisition of the discrimination of this study easier than learning with errors for adult mental retardates, and a history of errors on the discrimination detracted from the performance under errorless learning conditions. These results may be considered to confirm similar findings reported by Sidman and Stoddard (1967), and Touchette (1968) among mentally retarded children, and to indicate that these principles may be extended from child to adult retardates.

The data showed no difference between the two levels of source of retardation, and there was no interaction indicated by the results of the two-way analysis of variance. These results support the findings of Zeaman (1965), that cause of retardation is not a variable factor in the acquisition of a discrimination by mental retardates. It was not possible to compare the results of this study with the Zeaman (1965) report that acquisition of a discrimination by mental retardates is related to M.A. and I.Q., due to the lack of reliable M.A. or I.Q. scores for the sample.

Responses to the criterion discrimination yielded learning curves for the acquirers among both sources of retardation and all three experimental groups that were strikingly similar. All *S*s responded at chance performance until learning started, and then improved rapidly to accuracies of 90% or better (the percentage of *S*'s first-correct-response trials averaged over the 10 most recent trials). The mean learning curves for all six categories rose from chance performance to 90% first-correct responses in fewer than 20 trials, and were characterized by an ogival shape. Eliminating the plateaux due to chance performance by superimposing the terminal points of the curves produced mean backward learning curves (Hayes, 1953), and allowed group comparisons. Mean backward learning curves for the two condition factors are compared in Fig. 7. Learning rate, or the slope of the curves, is essentially the same for both mongols and non-mongols. Mean curves for all learners in each of the three experimental groups are shown in Fig. 8 (p. 28) with similar small differences in the slopes. The difference in ease of acquisition appears as the number of trials required for learning to commence. For all *S*s, the variable that was measured appears to be a factor proportional to the number of trials before learning started. Zeaman suggested that differences in the length of the initial plateau observed among child retardates may be due to "inattention to the relevant aspects of the stimuli." and that "duller children start out attending to the incorrect dimensions first [1965, p. 115]."

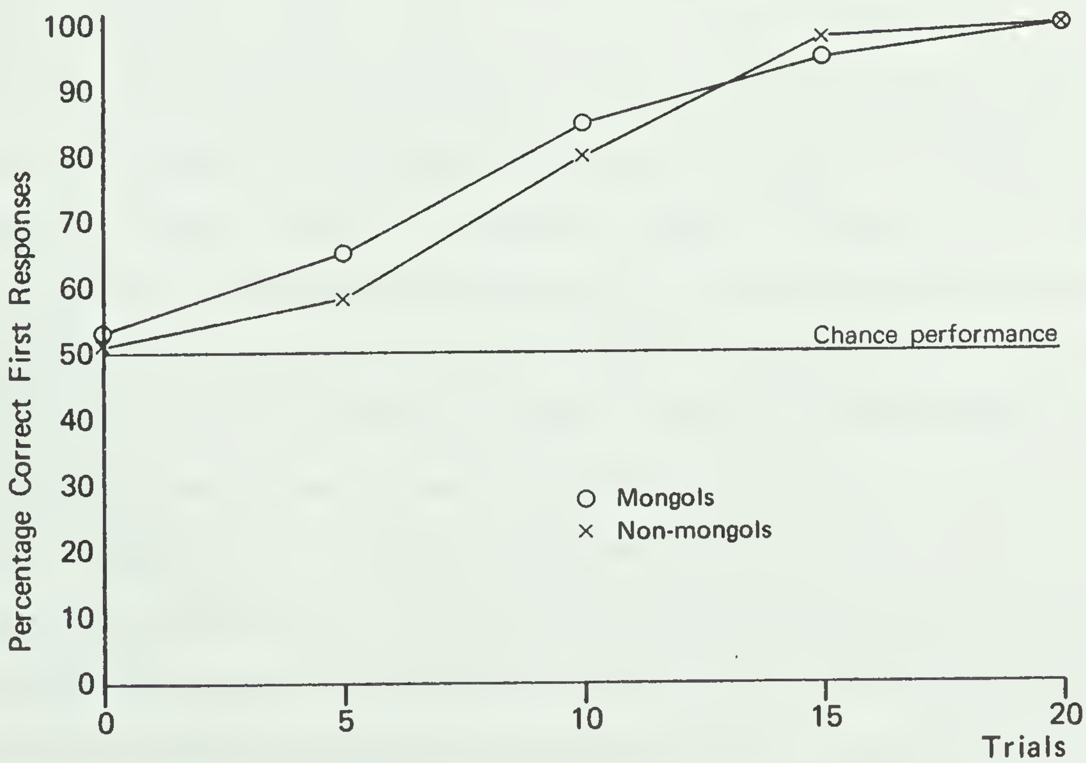


Fig. 7. Mean backward learning curves for learners by condition factor, on the discrimination criterion.

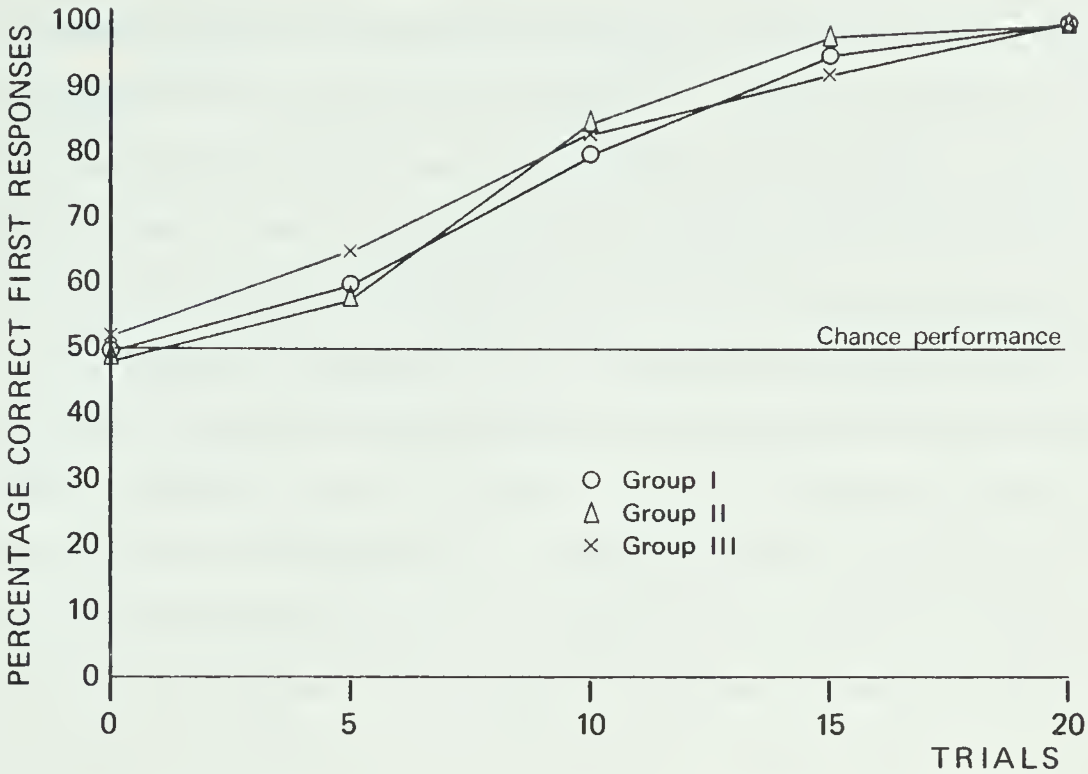


Fig. 8. Mean backward learning curves for learners by groups, on the discrimination criterion.

Research Suggestions

The present study has indicated that there may be similarities between retarded children and adults in the source of difficulty in acquiring a discrimination, that results of research with animal *S*s on the problem of attention (see for example Reynolds, 1961) may be useful in research with humans, and that the acquisition process may have at least two facets characterized by a plateau and an ogival curve, each of which may require different procedures for a more careful analysis. The methods used in the present study are relatively insensitive to the nature of the learning curve, and it can only be concluded that the curves appear similar in form relative to the more obvious differences in the lengths of the plateaux. A useful area for further research may be a more careful examination of the rapid learning phenomenon reported by Zeaman (1965) and observed in the present study. The magnitude of the observed differences before learning occurred suggests that behaviour during the chance performance period for both learners and non-learners should be studied to attempt to identify the controlling relationships that may exist. Such research may be close to sources of difficulty in discriminative learning encountered by retardates. Whether or not attention is a cause of difficulties among retardates is theoretical (Zeaman & House, 1963), and has not been empirically demonstrated, and the question of what aspects of stimuli differentially gain control during the pre-learning process needs to be clarified.

The results of the present study have suggested that there are factors that may change during the period when errors are as frequent as correct responses, whereby certain conditions must be achieved for learning, as defined in this study, to commence. Research to identify the factors and control the conditions that are associated with errors becomes important if procedures are to be devised to aid the non-learner to overcome his difficulties.

One of the more interesting results of this study is the similarity of the behaviour of adult and child retardates. If certain principles may be extended from animals to humans, or from children to adults, it may be efficient to test the extension of other principles that have been established with animals and retarded, or normal, children not only by those researchers who are interested in adult retardates, but also by those who are interested in a full analysis of the behaviour of all organisms in terms of fundamental principles and the conditions under which they are true. In the case of those principles that may underlie the behaviour of both child and adult retardates, more is suggested than the observation that such principles extend across certain species or groups. If it is assumed that child retardates normally become adult retardates, the principles can then be identified as those underlying the behaviour of a group of humans independent of developmental status. Such principles, it is suggested, are of a decidedly fundamental nature.

Conclusions

While it seems clear that trial and error experience had a detrimental effect on training in the present study, it is not so clear what variables affected the subsequent acquisition under programme control. This study was not designed to examine the nature of the interaction between *S* and the environment during trial and error training, but it becomes important, as a result of the demonstrated deleterious effects of such training, for researchers to attempt to describe the trial and error process among retardates and identify the controlling factors causing inappropriate behaviour. Reynolds (1961) showed that reinforcement alone could not prevent the development of inappropriate behaviour due to control by irrelevant aspects of the stimulus. Touchette pointed out that superstitious behavioural patterns may persist among retardates, and "seem to prevent the development of any appropriate controlling relations [1968, p. 48]." if they develop early in discrimination training. Reynolds (1961), Terrace (1963*b*), Skinner (1965), and Ray (1967) are among those who have shown that behaviour among animals may come under the

control of certain aspects or elements of a stimulus, while Touchette (1969, p. 211) used similar procedures to demonstrate that different aspects of a stimulus controlled the discriminative responses of severely retarded boys. Two conclusions are suggested by the foregoing; one is that research can and should investigate the nature of stimulus control in discriminative learning by mental retardates in order to understand the cause of behaviour, and the second is that the relatively heavily documented results of research into animal behaviour can be usefully employed in the design of studies for the analysis of mental retardate behaviour.

Touchette (1968, 1969), while working within the framework of contemporary experimentalist research techniques in the analysis of behaviour, has shown a sensitivity to the practical needs of those concerned with the training of retardates that has not always been demonstrated by others. He stated:

> Tedious though it may be to establish a graduated series of training stimuli which insure continuity of stimulus control, the startling effectiveness and economy of the program, once perfected, amply justify the work necessary to develop it. Further, some retardates who give the appearance of being untrainable, may in fact be the victims of training techniques which generate perseverative error patterns. For them, a programmed graduated stimulus training procedure may provide the only means for discovering their true potential [1968, p. 48].

It may be that such conclusions still fall short of the support sought by many charged with the welfare and training of mental retardates. How, for example, does one design an errorless training programme for tying a shoelace? What are the stimuli, the reinforcers, or the errors? Which responses are under the control of which stimuli? These are the questions that have to be answered by those who seek to apply the knowledge gained as a result of basic research. It is, therefore, incumbent upon institutions that are equipped to undertake applied research to develop the applied programmes. Such development, with the parallel development of basic research, each cognizant of the problems and results of the other, could result in the meaningful and useful progress envisioned by Staats (1968).

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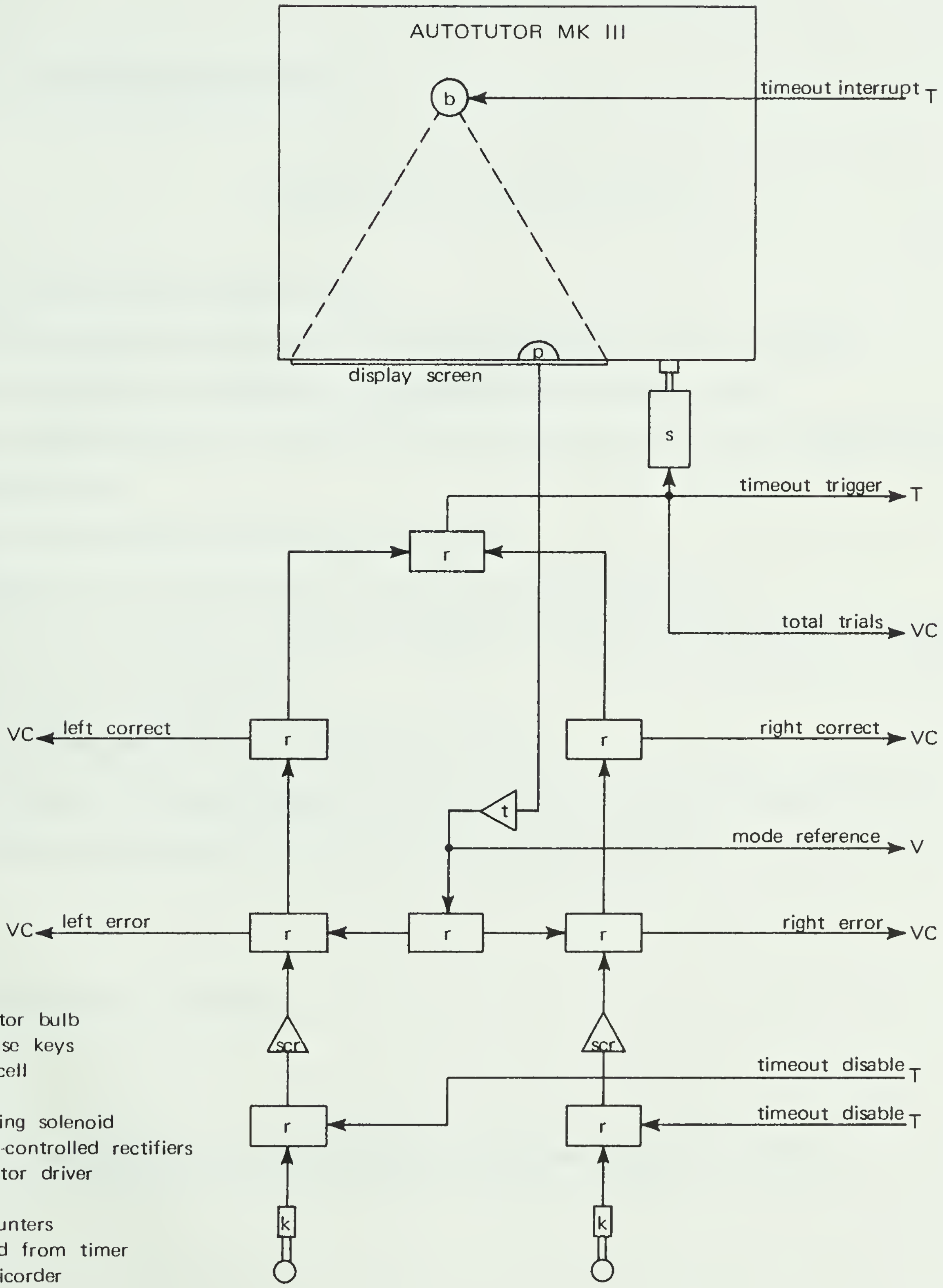
APPENDIX A



b projector bulb
k response keys
p photocell
r relays
s actuating solenoid
scr silicon-controlled rectifiers
t transistor driver

C to counters
T to and from timer
V to visicorder

ELECTRONICS SYSTEM TO ACTUATE THE PROJECTOR AND RECORD THE RESPONSES

Appendix B

JOHN W. MONNER (Experimenter)

INSTRUCTIONS TO THE SUBJECT

This is a test to see how well you learn.

Please keep looking at the screen. Do you see the pattern? *(Wait for response)*

One of these two keys will remove the pattern from the screen. *(Point)*

When a pattern comes on, I would like you to press the key that you think will remove it from the screen.

Only one of the two keys will remove the pattern.

I would like you to learn which key to press to remove the pattern.

If you learn to press the correct key regularly without making mistakes, you will earn a dollar. *(Show a new dollar bill)*

Do you understand what to do? *(Wait for response)*

Do you want to ask any questions? *(Answer as necessary by repeating instruction(s))*

Go ahead and press a key. *(Repeat after 30 seconds if necessary)*

(Continue session to criterion)

Please do not tell the others what you have been doing. *(Reward one dollar)*